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BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

The present invention relates generally to scuba diving equipment and more specifically to an improved second stage regulator having a flow demand valve that is free floating during periods of depressurization and is independently adjustable relative to a valve seat for optimal performance during pressurization. This provides a fluid tight seal during use but with little or no contact pressure during non-use.

PRIOR ART

Conventional pressure regulating devices intended for SCUBA diving typically comprise a demand pressure reduction valve that comprises a valve member that is held under constant spring force against a resilient valve seat. One end of the valve member has a sharp edged orifice that seals against the resilient seat. The resilient valve seat is typically housed in a metal or plastic member (poppet) that aligns the seat and provides for some mechanical linkage to retract the seat from the orifice to initiate fluid flow. Upon inhalation, the vacuum created in the housing of the regulator draws a diaphragm against a lever that in turn mechanically retracts the poppet containing the resilient valve seat away from the orifice and allows fluid flow through the valve. During exhalation, the diaphragm returns to its normal position and the spring returns the lever and poppet to the closed position.

1 The spring force needed to seal the orifice to the resilient
2 seat without leakage is usually constant and of sufficient
3 force to cause degradation and distortion of the resilient seat
4 over a period of time, especially in the depressurized (non-
5 use) condition. Distortion of the seat results in decreased
6 flow and degraded performance of the valve. Numerous
7 inventions have been tried to lessen the effect.

8
9 Thus, there is a need in the scuba diving industry for an
10 improved second stage regulator which provides for spring
11 relaxation as an anti-set feature during non-use of the
12 regulator.

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14 A search of the prior art has revealed the following patents
15 which are deemed to be relevant to the present invention in
16 varying degrees:

17 —
18 4,094,314 Le Cornec
19 4,159,717 Cossey
20 4,356,820 Trinkwalder, Jr.
21 4,834,086 Garofalo
22 5,343,858 Winefordner et al
23 5,411,053 Markham et al
24 5,419,530 Kumar
25 5,437,268 Preece
26 —

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28 U.S. Patent No. 4,834,086 to Garofalo is directed to a second
29 stage regulator for an underwater air breathing apparatus with
30 a floating piston that opens the second stage valve during
31 periods of non-use to prevent distortion of the valve seat and
32 the resultant alteration of calibration. When compressed air

1 is applied to the input fitting 7 of valve 4, a valve seat
2 mounting member 8, a floating piston, is forced by the input
3 air against biasing spring 608 into engagement with the bottom
4 of chamber 204 and seat 508 mounted on the floating piston in
5 gauge valve 3. Breathing by the user opens valve 3 through the
6 action of monostat diaphragm 12 and lever 2. The air flow
7 through valve 4 results in a pressure drop upstream of the
8 floating piston, resulting in spring 608 moving the piston back
9 away from valve 3 increasing the air flow to the user at parity
10 with the inhalation effort.

11
12 U.S. 4,094,314 to Le Cornec is directed to a second stage
13 pressure regulator that has a nozzle that is held in operating
14 position by the compressed inlet air and when not in use, the
15 nozzle is only lightly held against the sealing pellet so as to
16 cause no irreversible deformation and maladjustment of the
17 pressure regulator. An intermediate body member 4 holds nozzle
18 5 that is held lightly by spring 15 against the seat 5a of the
19 valve member 5. Pressurized air from the first stage regulator
20 applied to the inlet 1 forces the nozzle against the valve seat
21 for normal operation. The valve biased closed by spring 9 is
22 operated by membrane 19 through lever 11.

23
24 U.S. Patent No. 4,159,717 to Cossey is directed to an anti-
25 set protector for second stage scuba regulators. A removable
26 spacer 52 is provided to be interposed between the cover 50 and
27 flexible diaphragm 42 during storage of the regulator. The
28 spacer holds the valve assembly 20 open so that the closure 26
29 does not take on a compressive set with the resulting loss of
30 sealing ability.

1 Various devices have been used to mechanically move the
2 orifice away from the seat during non-use (Cossey) but these
3 devices are external to the valve and not automatic. They also
4 require removal before use. Not removing them will cause
5 temporary malfunction of the valve (loss of air). A floating
6 piston has also been used as a valve member before (Le Cornec,
7 Garofalo). A disadvantage of that design however is the lack
8 of an independent and precise adjustment of the position of the
9 valve member with respect to the resilient seat. It is
10 desirable to be able to fine tune the position of the orifice
11 with respect to the seat in order to achieve the least amount
12 of sealing force needed to close the valve. Using excessive
13 force to close the valve will conversely require excessive
14 force to open it. The goal is to provide a valve that is as
15 easy to initiate as possible to reduce the inhalation vacuum
16 (effort) required on the part of the user. Typically, there
17 are at least two adjustment means provided. One is the valve
18 member with respect to the resilient seat that is usually
19 accomplished by means of a threaded valve member and bore. The
20 second is an adjustment of the spring tension, usually
21 accomplished by changing the length of the spring
22 (Winefordner). The valve of Le Cornec and Garofalo combine the
23 two adjustments. The valve seat cannot be moved away from the
24 valve member without also relaxing the spring, and conversely
25 cannot be moved closer without increasing spring tension. The
26 adjustability of the valve is therefore limited to prevent
27 optimal adjustment and operation of the valve.

1 From the aforementioned prior art description it will be seen
2 that there is apparently no known prior art which provides an
3 anti-set pneumatically dependent relaxation feature in a second
4 stage scuba diving regulator. There is therefore a continuing
5 need for an improved second stage scuba diving regulator of the
6 type having a pneumatically dependent anti-set poppet seat.

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SUMMARY OF THE INVENTION

This invention provides a valve member that is both free floating during periods of depressurization (non-use) and independently adjustable in relationship to the resilient valve seat. This allows the valve to be adjusted for optimal performance and allows the valve member to retract away from the resilient seat automatically during periods of non-use which are typically very long compared to periods of use. The result is an adjustable valve that resists deformation of the resilient seat.

The parts of the valve are contained in an axial conduit. The conduit provides a threaded connection at one end for a pressurized hose (not shown). A portion of the inside bore of the conduit is threaded to receive an adjustable sleeve. The valve member orifice is free to slide axially in the bore of the sleeve, but is restricted in its forward travel by the sleeve. In this example, the bore of the sleeve is a six-sided hexagonal shape, and accepts the hexagonal shape of the forward portion of the valve member. In this manner, the valve member is keyed to the sleeve, and adjustment is provided by turning the orifice with a suitable tool, such as a screwdriver or hex wrench in a slot provided. Any shape to key the valve member to the sleeve such as a square or slot would serve the same purpose. It is preferred that the sleeve be of a low friction material to allow the orifice to slide with minimal force.

1 Upon pressurization, the O-ring seal on the rear of the valve
2 member moves it forward to the limit set by the adjustment
3 sleeve. The sleeve is adjusted until the orifice embeds into
4 the resilient seat just enough to provide a fluid tight seal.

5
6 Upon inhalation through the mouthpiece, the diver creates a
7 vacuum inside the regulator housing and the diaphragm retracts.
8 The diaphragm contacts the lever sliding on a low friction disc
9 in the elastomeric diaphragm, drawing it inward. The lever has
10 legs that penetrate both sides of the axial conduit through a
11 square hole. One side of the lever leg lies flat against the
12 side of the square hole and the other against the leg of the
13 poppet. As the lever leg pivots in the square hole, it pushes
14 the poppet and resilient seal away from the orifice, opening
15 the valve. During exhalation, the diaphragm returns to its
16 normal position, and the spring returns the poppet to its
17 sealing position.

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19 Upon depressurization, the valve member is free to retract
20 away from the resilient seal relieving contact pressure with
21 the orifice sharp edge as there is no longer any force other
22 than O-ring tension holding it in place. With little or no
23 force keeping the orifice in contact with the resilient seat,
24 it will not become deformed during long periods of non-use.
25 Thus, this anti-set feature is automatic when turning off the
26 regulator. To insure retraction of the seat, an optional thin
27 wave shaped spring washer may be located between the sleeve and
28 orifice and would provide enough force to insure positive
29 return of the orifice away from the resilient seal.

OBJECTS OF THE INVENTION

It is therefore a principal object of the present invention to provide an improved second stage regulator for scuba diving, the regulator having an automatic anti-set feature responsive to air pressure from the first stage to avoid deformation of the resilient valve seat during non-use.

It is an additional object of the present invention to provide an improved second stage regulator for scuba diving having a flow demand valve with a pneumatically activated valve orifice wherein a soft elastomeric seal engages a sharp-edge orifice only when the interior chamber of the regulator is pressurized and relaxes the orifice edge from the seal when the interior chamber of the regulator is unpressurized.

It is still an additional object of the present invention to provide an improved second stage regulator for scuba diving wherein an automatic anti-set feature comprises a pneumatically responsive valve orifice which is free floating during periods of depressurization of the regulator and which is forced to engage the seal during periods of pressurization of the regulator.

BRIEF DESCRIPTION OF THE DRAWINGS

The aforementioned objects and advantages of the present invention, as well as additional objects and advantages thereof, will be more fully understood hereinafter as a result of a detailed description of a preferred embodiment when taken in conjunction with the following drawings in which:

FIG. 1 is a cross-sectional view of the regulator of the present invention shown in its pressurized configuration;

FIG. 2 is an enlarged cross-sectional view of a portion of the regulator of the present shown in its pressurized configuration;

FIG. 3 is an enlarged cross-sectional view of a portion of the regulator of the present invention shown in its unpressurized configuration; and

FIG. 4 is a still further enlarged view of the orifice/seal portion of the regulator illustrating the pneumatically responsive feature thereof.

1 DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

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4 This invention provides a valve member 15 that is both free
5 floating during periods of depressurization (non-use) and
6 independently adjustable in relationship to the resilient valve
7 seat. This allows the valve to be adjusted for optimal
8 performance and allows the valve member to retract away from
9 the resilient seat automatically during periods of non-use
10 which are typically very long compared to periods of use. The
11 result is an adjustable valve that resists deformation of the
12 resilient seat.

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14 As seen best in FIG. 1, a breathing regulator 10 comprises an
15 axial conduit 12 in which is positioned valve member 15 having
16 a floating orifice 16 within a floating sleeve 14. The
17 regulator 10 also comprises a mouthpiece 18 extending from a
18 housing 20. A diaphragm 22 responds to a reduction in pressure
19 within a diaphragm cover 44 relative to ambient pressure
20 passages 42. The diaphragm 22 employs a low friction disc 26
21 which pushes a lever 24 causing a poppet 28 to retract a
22 resilient seal or seat 46 to withdraw from sharp edge 19 of
23 orifice 16 to permit air to flow into the regulator and through
24 mouthpiece 18 to a diver. ^(see FIG. 4) An O-ring 21 prevents pressure
25 leakage along the conduit 12. Another O-ring 17 serves the
26 purpose of assuring forceful urging of the floating orifice 16
27 against the elastomeric seal 46 whereby the sharp edge 19 is
28 embedded in the seal to assure valve closure until lever 24
29 pulls the seal and poppet to compress the spring 30 and open
30 the valve member 15. A pressure transmitting stem 38 feeds the
31 pressurized air into a pressure balancing chamber which assures
32 return of the seal to close the valve member when the lever is

1 relaxed upon exhalation through the mouthpiece. A spring
2 tension adjuster 36 co-acts with spring 30 to return the seal
3 when the chamber 40 balances the pressure in the regulator.

4
5 As seen in FIG. 4 the parts of the valve are contained in an
6 axial conduit 12. The conduit provides a threaded connection
7 at one end for a pressurized hose (not shown). A portion of
8 the inside bore of the conduit is threaded to receive an
9 adjustable sleeve 14. The valve member and orifice 16 is free
10 to slide axially in the bore of the sleeve, but is restricted
11 in its forward travel by the sleeve. In this example, the bore 23
12 of the sleeve is a six-sided hexagonal shape, and accepts the
13 hexagonal shape of the forward portion²⁵ of the valve member. In
14 this manner, the valve member is keyed to the sleeve, and
15 adjustment is provided by turning the orifice with a suitable
16 tool, such as a screwdriver or hex wrench in a slot 13
17 provided. Any shape to key the valve member to the sleeve such
18 as a square or slot would serve the same purpose. It is
19 preferred that the sleeve be of a low friction material to
20 allow the orifice to slide with minimal force.

21
22 Upon pressurization, the O-ring seal 17 on the rear of the
23 valve member moves it forward to the limit set by the
24 adjustment sleeve 14. The sleeve is adjusted until the orifice
25 16 embeds into the resilient seat 46 just enough to provide a
26 fluid tight seal.

27
28 As seen in FIG. 2, upon inhalation through the mouthpiece 18,
29 the diver creates a vacuum inside the regulator housing 20 and
30 the diaphragm 22 retracts. The diaphragm contacts the lever 24
31 sliding on a low friction disc 26 in the elastomeric diaphragm,
32 drawing it inward. The lever 24 has legs 32 that penetrate

1 both sides of the axial conduit 12 through a square hole 34.
2 One side of the lever leg lies flat against the side of the
3 square hole and the other against the leg of the poppet 28. As
4 the lever leg pivots in the square hole, it pushes the poppet
5 and resilient seal 46 away from the orifice, opening the valve.
6 During exhalation, the diaphragm returns to its normal
7 position, and the spring 30 returns the poppet to its sealing
8 position.

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10 As seen in FIG. 3, upon depressurization, the valve member 15
11 is free to retract away from the resilient seal 46 relieving
12 contact pressure with the orifice sharp edge 19 as there is no
13 longer any force other than O-ring tension holding it in place.
14 With little or no force keeping the orifice 16 in contact with
15 the resilient seat 46 it will not become deformed during long
16 periods of non-use. Thus, this anti-set feature is automatic
17 when turning off the regulator 10. To insure retraction of the
18 seat, an optional design would include a thin wave shaped
19 spring washer (not shown) between the sleeve 14 and orifice 16
20 that would provide enough force to insure positive return of
21 the orifice away from the resilient seal 46.

22
23 Thus it will be understood that the present invention
24 provides a significant improvement in the art of breathing
25 regulators. The invention provides an anti-set feature wherein
26 a floating orifice member responds to pressurization by
27 forcefully engaging a resilient seal with a sharp edge orifice
28 and responds to depressurization by permitting disengagement
29 between the seal and sharp edge orifice and thus avoid a
30 reduction in long term seal integrity. Furthermore, the unique
31 structure of the regulator disclosed herein permits adjustment
32 of the travel limit of the floating orifice member during

1 pressurization so that optimum performance may be achieved.

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3 Those having skill in the art to which the present invention
4 pertains, will now, as a result of the disclosure made herein,
5 perceive various modifications which may be made to the
6 invention. By way of example, the structure of the valve
7 member may be readily altered to provide other ways of limiting
8 the travel of the floating orifice as well as of varying such
9 limits to adjust performance parameters. Accordingly, such
10 modifications are deemed to be within the scope of the
11 invention which is to be limited only by the claims appended
12 hereto and their equivalents.

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